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ABSTRACT

In an investigation of 1-year-olds' ability to plan a sequence of steps, 20 infants were administered a compound means-ends problem. In a planning condition, a barrier was placed in front of a cloth at the far end of which was placed one end of a long string. A toy was fastened to the other end of the string and was placed on a table at some distance from the cloth. To retrieve the toy, the infant had to remove the barrier, pull the cloth, and grasp and pull the string. In a control condition, the same arrangement of barrier, support, and string was used, but the toy was visibly separate from the string. Each infant was given five trials on both conditions with order counterbalanced. Findings revealed that when the toy was fastened to the string, infants were more likely to remove the barrier without playing with it, were quicker to reach for the support, and retrieved the string more frequently. When the toy was separate from the string, infants played more with the barrier, were much slower to contact the support, and often failed to retrieve the string. Order of task had no effect on performance. Results indicate that 12-month-olds are able to plan a series of steps to achieve a goal, and are not restricted to the use of trial-and-error methods in which problems can only be solved by proceeding one step at a time. (Author/RH)

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PLANNING BY 12-MONTH-OLD INFANTS

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Running Head: Planning in infants

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ABSTRACT

Infants aged 12 months were given a compound means-ends problem in which they were required to remove a barrier, pull a support, grasp a string resting on the support, and pull it to retrieve a toy. In a control condition, the same arrangement of barrier, support and string was used, but the toy was visibly separate from the string. Each infant was tested on both tasks. When the toy was fastened to the string, infants were more likely to remove the barrier without playing with it, were quicker to reach for the support, and retrieved the string more frequently. When the toy was separate from the string, infants played more with the barrier, were much slower to contact the support, and often failed to retrieve the string. Order of task had no effects on performance. These results indicate that 12-month-olds are able to plan a series of steps to achieve a goal, and are not restricted to the use of trial-and-error methods in which problems can only be solved by proceeding one step at a time.

PLANNING BY 12-MONTH-OLD INFANTS

According to Piaget (1953), infants begin to plan solutions to problems at the end of the sensory-motor period when the capacity for mental representation first develops. With the onset of representation in stage VI, infants can recall actions, anticipate their effects, and coordinate them into effective sequences without any need for information supplied through activity (Willatts, 1989). Problem solving prior to stage VI is unplanned and must be carried out in "real time" because the young infant is unable to represent a sequence of steps which might lead to a goal. Early problem-solving strategies are therefore based on some form of overt trial-and-error or forward search, and the infant has to try out each action to discover whether it will work or not.

Although Piaget's view is still widely accepted, there are difficulties with his account. First, there is a growing body of evidence which shows that he underestimated the abilities of young infants. Studies of object permanence, deferred imitation, recall memory, and making inferences suggest that young infants do possess a capacity for representation which could support a simple type of planning (Willatts, 1989, and in press). Second, Piaget's own evidence for the onset of planning in stage VI is weak, and a more reasonable explanation for his observations is that infants were using a more efficient form of trial-and-error (Willatts, Domminney, & Rosie, 1989). In fact, much of Piaget's evidence for stage VI planning is ambiguous, and it is possible that the use of planning by younger infants may have gone unnoticed.

One study which suggests that 9-month-old infants can plan a sequence of steps to solve a compound means-ends problem was reported by Willatts (1984). The task required infants to coordinate existing means-ends skills for removing an obstacle to a goal, and pulling a support to retrieve an object resting on it.

A planning group of infants was given a task in which they had to remove a barrier (a large block of foam), grasp a cloth, and pull it to recover a toy on the far end. A control group was given a similar task, but the toy was placed on the table beside the cloth and could not be retrieved. If infants were able to use their knowledge of barriers and supports to plan a solution, then the planning group should have removed the barrier in order to pull the cloth and recover the toy. Infants in the control group would know that the toy could not be retrieved, would be less interested in the cloth, and therefore would be less likely to remove the barrier and approach the cloth. Alternatively, if the infants were unable to make a plan, then both groups would have approached the barrier in the same way and worked through each step in a trial-and-error fashion. Thus, evidence for a planned solution would be provided by the infants' first activity with the barrier.

The results supported a planning interpretation. Infants in the planning group removed the barrier without playing with it, reached quickly for the cloth and retrieved the toy. In contrast, infants in the control group played more with the barrier, were much slower to contact the cloth, and tended to ignore it completely. It was also clear that the groups differed from the very first trial, so their performance could not have been the result of learning over trials. This finding suggests that the infants had planned a sequence of actions and that their first activity with the barrier was determined by what they intended to do next.

However, Wellman, Fabricius, and Sophian (1985) offered an alternative interpretation. They suggested that perhaps at the start of a trial, infants in the planning group did not really care that the toy and cloth were separate and simply regarded them as a combined toy-cloth object. The task would then have been a more straightforward means-ends problem of removing a barrier to obtain a

goal. The differences between the groups might have arisen because the cloth-toy looked more attractive than the cloth on its own, and so infants in the planning group were more willing to retrieve it. Having done so, they then decided to use the cloth to recover the toy. This decision could have been taken *after* the barrier was removed and not *before*, and the solution, although planful, would not have entailed planning a sequence of steps.

The following study was designed to overcome this criticism and provide clearer evidence for early planning. A group of 20 infants with a mean age of 12 months (51.9 weeks) was tested on a more complex version of the original task which required three steps for a solution. In the planning condition there was a barrier in front of a cloth, at the far end of which was placed one end of a long string. A toy was fastened to the other end of the string and was placed on the table at some distance from the cloth. To retrieve the toy, the infant had to remove the barrier, pull the cloth, grasp the string, and pull it. In the control condition the barrier, cloth and string were all in the same positions, but the toy was not attached to the string and could not be retrieved (Fig. 1). Each infant was given 5 trials on both conditions with order counterbalanced.

[Figure 1]

An important feature of this new task was that the appearance of the cloth was equivalent in both conditions. Once the barrier had been picked up, the infant had access to the same combination of cloth and string. This means that differential attractiveness could not be responsible for any differences in performance. Any evidence for a more rapid or direct approach to the cloth in the planning condition would indicate that the infants had appreciated its function as an intermediary and planned what to do.

There were clear differences in the way infants set about the tasks, and a summary of the main results is given in Table 1. Infants ignored the barrier altogether on significantly more trials for the control task, Wilcoxon T=0, n=6, $p<.05$, (two-tailed). The barrier was removed without any play on significantly more trials on the planning task, $F(1,18)=19.8$, $p<.001$, and play with the barrier occurred more often on the control task, $F(1,18)=10.6$, $p<.01$. Infants were much quicker to make contact with the cloth on the planning task, and the interval between contacting the barrier and contacting the cloth was significantly shorter, $F(1,18)=7.0$, $p<.05$. In addition, infants on the planning task went on to retrieve the string on significantly more trials, Wilcoxon T=2.5, n=18, $p<.001$, (two-tailed). One reason for this difference was that infants frequently refused to contact either the barrier or the cloth on control-task trials. When all such trials were excluded, there was still a significant difference with infants retrieving the string on more trials for the planning task, Wilcoxon T=17, n=13, $p<.05$, (two-tailed). There were no effects on any measure due to order of tasks, and no order x task interactions were significant. Infants adjusted their performance as soon as the task was changed and regardless of which came first.

[Table 1]

Examination of performance on trial 1 for each task did not reveal any significant differences in the frequency of removing the barrier without play, barrier-cloth interval, or retrieving the string. However, comparison of performance on the final trial of the task presented first, and the initial trial of the task presented second, did show significant changes on these measures, and regardless of the order of the tasks. Thus, after the changeover from one task to another, infants on the planning task removed the barrier without play more

often, two-tailed sign test, $p<.05$, were quicker to contact the cloth, $F(1,18)=6.4$, $p<.05$, and were more likely to retrieve the string, two-tailed sign test, $p<.02$.

These results suggest that infants needed time to settle into the tasks, possibly because they appeared somewhat confusing with so many objects set out on the table. However, the fact that performance altered immediately when the condition was changed and regardless of the order of presentation, suggests that once infants had become familiar with the general procedure, they were able to plan what to do. If infants were unable to plan and had merely tried to retrieve the cloth, their behavior should have been the same in the two conditions because the arrangement of the barrier, cloth, and string was equivalent. However, there was no indication that they were proceeding one step at a time, and the first activity with the barrier on the planning task was directed toward the ultimate goal (Fig. 2).

[Figure 2]

This study shows that 12-month-old infants are able to plan a sequence of steps in which the goal is reached after the achievement of three subgoals. It is not possible to say with certainty just how much of the sequence was planned out in advance, but infants must have considered at least the first two steps and planned to remove the barrier in order to pull the support. Whether they also included the final step of pulling the string in this plan or thought about it after they had grasped the cloth remains unclear and requires further investigation. This finding shows that 12-month-old infants can think beyond the first step of a compound means-ends problem, and adds to the growing evidence for the existence of an early representational capacity in the first year of life.

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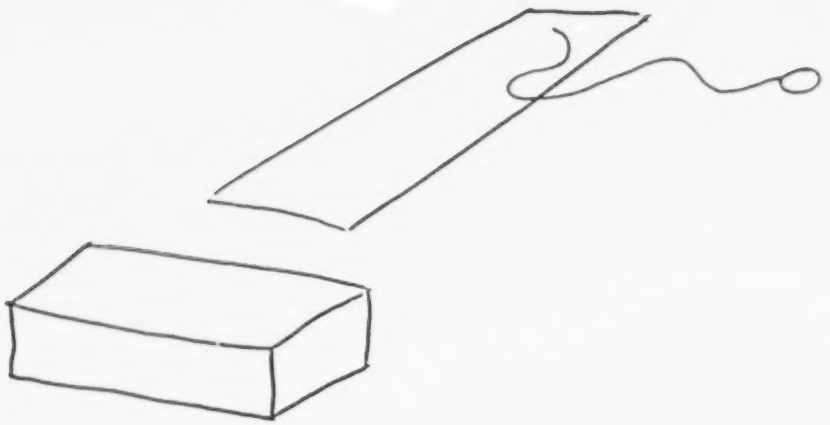
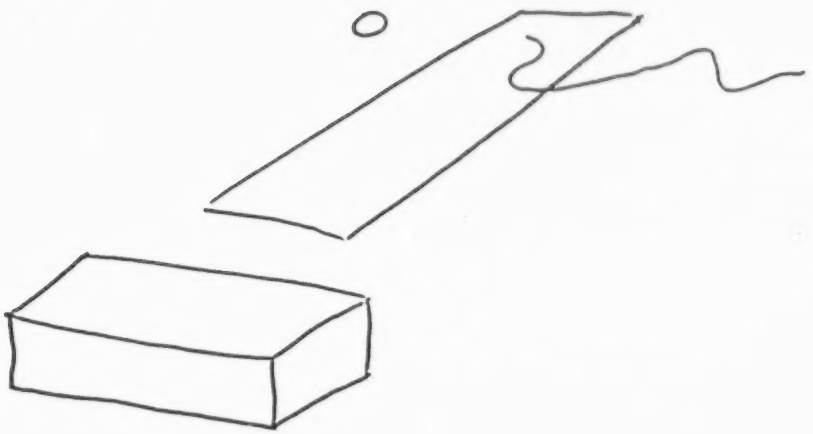
Table 1: Type of barrier behavior, mean barrier-cloth contact interval, and proportion of trials on which string was retrieved by 12-month-old infants on planning and control tasks.

	Task	
Barrier behavior (Percent trials)	Planning	Control
Remove barrier	67.0	32.0 ***
Play with barrier	15.0	39.0 **
Ignore barrier	3.0	15.0 *
Mean barrier-cloth contact interval (sec)	7.4	13.6 *
Percent trials on which string was retrieved		
All trials	80.0	34.0 ***
Trials on which cloth was contacted	83.0	61.0 *

* $p<.05$
** $p<.01$
*** $p<.001$

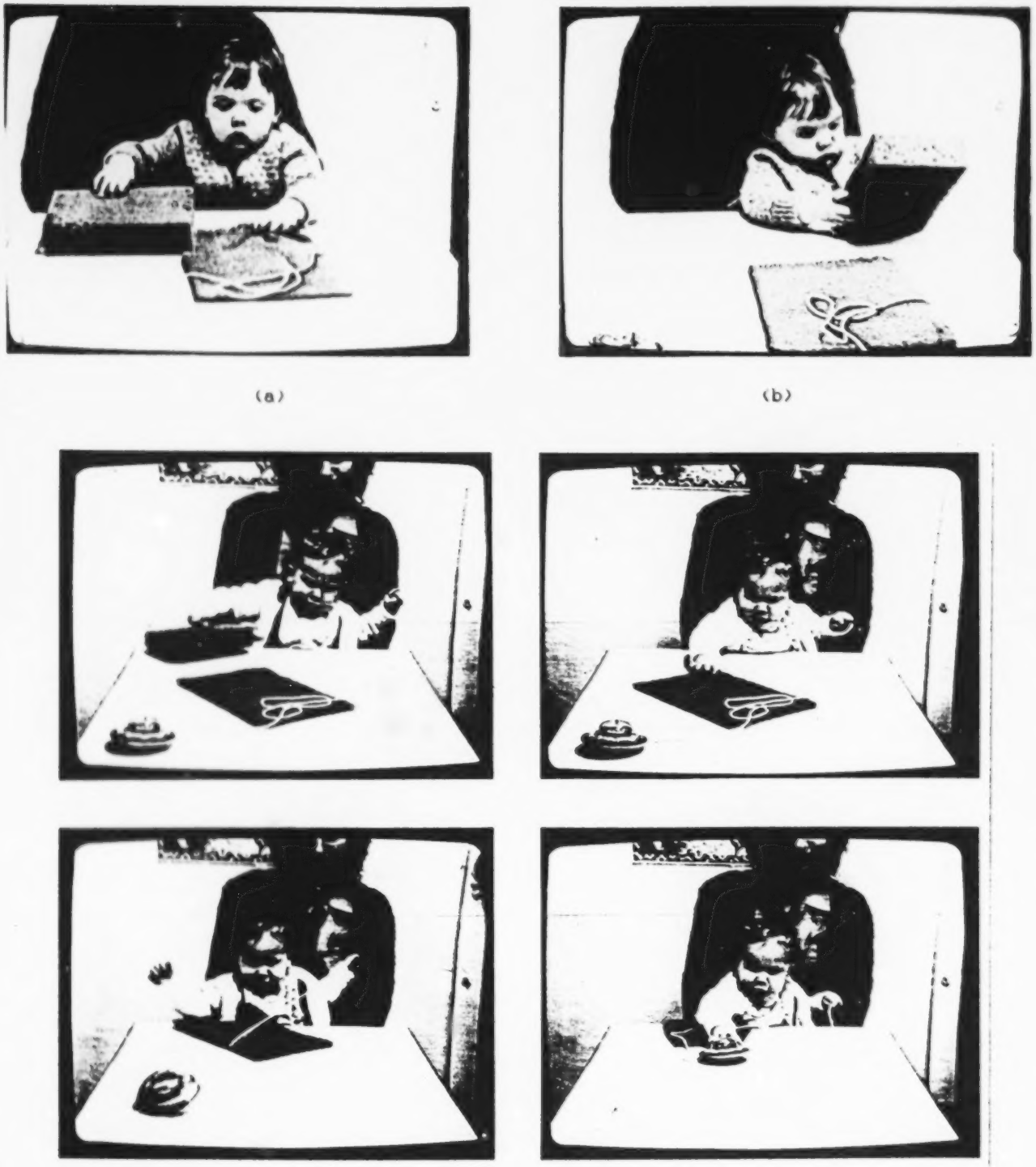


(a) Planning task



(b) Control task

Fig. 1: Arrangement of barrier, cloth, string, and toy on (a) planning task, and (b) control task.



(a) (b)

Fig. 2: (a) Infant in planning condition removes barrier to grasp cloth. (b) Same infant in control condition plays with barrier. The lower sequence shows another infant working rapidly through each step to recover the toy.